PRELIMINARY ASSESSMENT OF FEDERAL NEED FOR CURRENT AND FUTURE OCEAN TECHNOLOGY

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SUMMARY

This report is a preliminary assessment of technological needs and requirements for Federally supported marine programs. Although a brief forecast of future government needs is provided, the primary objective was to look at present needs.

An initial goal was to determine the priorities of technological research and development programs. This goal was not attainable owing to the wide diversity of programs and the autonomous nature under which they are conducted. Since there is no National ocean program and no National ocean objectives, it is all but impossible to assign priorities to programs. There is no single publication from which a comprehensive listing or description of all Federal marine programs can be obtained. Consequently, it is not possible to discern priorities simply on the basis of subject emphasis.

Owing to the lack of a comprehensive source which identifies all Federally funded ocean programs, it is not possible to obtain an accurate estimate of the comprehensiveness of this study. By using reports which describe Federal marine technology programs of the late 1960s and early 1970s, it is estimated that this study covers somewhere in the neighborhood of 25 percent of current activities.

Thirteen Federal agencies have an interest in the marine environment. Of these, only seven (excluding NASA) are actively involved in technological developments; these are: the Departments of Commerce, Defense, Energy, Interior and Transportation, and the Environmental Protection Agency and National Science Foundation. Within these activities 150 technological needs/requirements were identified. Thirty seven percent are directed toward component hardware development; 51 percent are concerned with ocean instrumentation development; 9 percent are analytical requirements, 2 percent are materials research and 1 percent are data processing needs.

A variety of sources are employed to conduct research and development for Federal programs. These can be in-house laboratories; academic institutions; non-profit organizations; industrial contractors or other government agencies.

The parochial nature of Federal ocean programs produces a diversity of technological needs. In most instances a requirement for a specific piece of hardware or a specific instrument will have application only to the particular program responsible for its development. However, the function it is serving or the environmental characteristic it is measuring can be of

mutual interest to different agencies. Consequently, there is a commonality in purpose, but not in specifics. Projects in which such commonality exists are in the following areas: sub-sea materials; inspection/monitoring of structures; data acquisition techniques; underway sampling; current measurements; wind/wave stress measurements; laser applications; mapping/surveying and pollutants.

It is anticipated that the decade of the 1980s will see increasing Federal activities in ocean programs related to energy (oil and gas), pollution monitoring and control, scientific research and, possibly, deep sea mining. (These are exclusive of surface transportation and military interests.) In the energy area the recovery of oil and gas will move into deeper and more hostile waters. Present techniques for coping with inspection, maintenance and repair of offshore structures rely heavily on the diver. However, projected drilling depths of 2,000m preclude use of the diver and no manipulative techniques are now available which will replace him. Blowouts below 450m, similar to the recent Mexican incident, will be all but impossible to control without direct, in situ diver intervention. There is a pressing need, therefore, for a major development program in mechanical manipulation systems which can equal the dexterity and tactile capabilities of the human hand and which can be deployed from manned and remotely operated vehicles.

If extraction of oil and gas moves into the Arctic regions, and economically viable deposits are found under ice, then conventional techniques used in surveying, exploration, development and production will not be applicable. Instead, remotely operated untethered vehicles with thru-water, real-time TV and data signal transmitting capabilities will be required.

Scientific and pollution control/monitoring efforts of the 1980s will require greater depth capabilities, greater detail in measurements, long term measurements and more data obtained in situ. These needs will require substantial development in supporting technologies, such as: deep sea navigation, sub-surface power supplies, data processing, storage and telemetry and sub-sea vehicles.

Accurate and comprehensive funding figures for current Federally-funded ocean technology development were not obtainable. Overall funding estimates for various Federal activity were, however, attainable, and are as follows (in respect to ocean activities only):

	(Millions)
Department of Commerce (NOAA)	$792.5
Department of Defense (ONR)	33.0
Department of Energy (Ocean Systems Branch, Div. of Waste Isolation)	41.9
Department of Interior (Conservation Div., Office of Marine Geology)	20.4
Department of Transportation (Pollution Surveillance, Response)	3.0
National Science Foundation	68.7
	$959.5

PURPOSE OF THE STUDY

The objectives of this study were the following:

- identify key existing and planned civil programs and program priorities.
- include a review of reports issued since 1969 and of those planned together with a summary of the needs predicted and coarse description of needs still unfulfilled.
- identify key mission agencies and contact points within agencies, adademic and research institutions.
- identify capabilities within the mission agencies and institutions for addressing priority needs.
- estimate the commonality of technology needs among the key mission agencies.

In light of time constraints and the numerous published reports and studies dealing with Federal ocean activities and recommendations, this study was not designed as a comprehensive and original study of needs. The purpose is to provide information to the National Aeronautics and Space Administration's (NASA) Technology Transfer Office on the status of Federal marine programs. Specifically, their technological needs, priorities and capabilities. Only those programs in the offshore marine environment were considered.

APPROACH

The data herein is derived from two sources: 1) personal interviews with pertinent government and quasi-governmental personnel in the metropolitan Washington area, and 2) a review of reports and studies published by the Federal marine community in the past decade. In the course of the personal interview phase 39 individuals were contacted representing 11 different activities. These individuals and their affilitations are listed in Appendix A. In the literature review phase 76 reports/studies were thoroughly reviewed and pertinent information extracted. These reports are referenced in Appendix B. Approximately 70 percent of the technological needs/requirements tabulated in this study were obtained from the literature survey; 30 percent were obtained from personal interviews.

Fourteen man weeks of effort was expended during the period 19 November 1979 through 28 January 1980 to conduct the interviews and collect/review the literature.

PLANNED AND EXISTING PROGRAMS

There are a wide variety of Federal civil oceanographic programs which are currently being pursued and which are recommended. Some have been on-going for many years, some are new starts and others are simply recommendations for technological research and development. The existing programs are not designed to dovetail at some point in the future to satisfy a common national need. Most programs operate much like fiefdoms, in that, they operate independently of other programs, have goals which are independent of other programs and jealously protect their interests (i.e., funding) against incursion from the outside (i.e., competing government programs). An appreciation for the diversity of ocean interests can be gained from Figure 1.

A 1974 report, Engineering in the Ocean, by the National Advisory Committee on Oceans and Atmosphere (NACOA) summed up the Federal civil situation in the following statement:

> "Government tasks are so endless, the requirements for program and budget justification so detailed, it was not surprising that ready-made plans exist to take ocean engineering one more step in about any direction named. The price however is a somewhat sluggish responsiveness to new problems and there seems not yet to have emerged forward-looking definition of what needs to be done, in the offshore zone in particular, with regard to ocean engineering aspects of multiple use, regulation, safety, environmental protection, and the like."

A memorandum report by the Ocean Engineering Panel of NACOA addressed the "ocean engineering problem" as follows:

> "- The ground has been well-ploughed.
> - There is no question but that there are things to do in ocean engineering but too many to do all at once.
> - There is no general agreement on what projects or programs ought to be done first.
> - This may be because no one thing ought to be worked on first and many ought to be worked on simultaneously.
> - Drifting along until we hit a snag seems hardly the useful way to go."

As stated earlier in this study, 76 published and unpublished reports were reviewed. The review was aimed specifically at extracting requirements, needs and/or forecasts for technological developments. In this respect the quantity of reports examined did not yield the results anticipated. By and large the reports deal with needs and requirements in terms of "understanding"

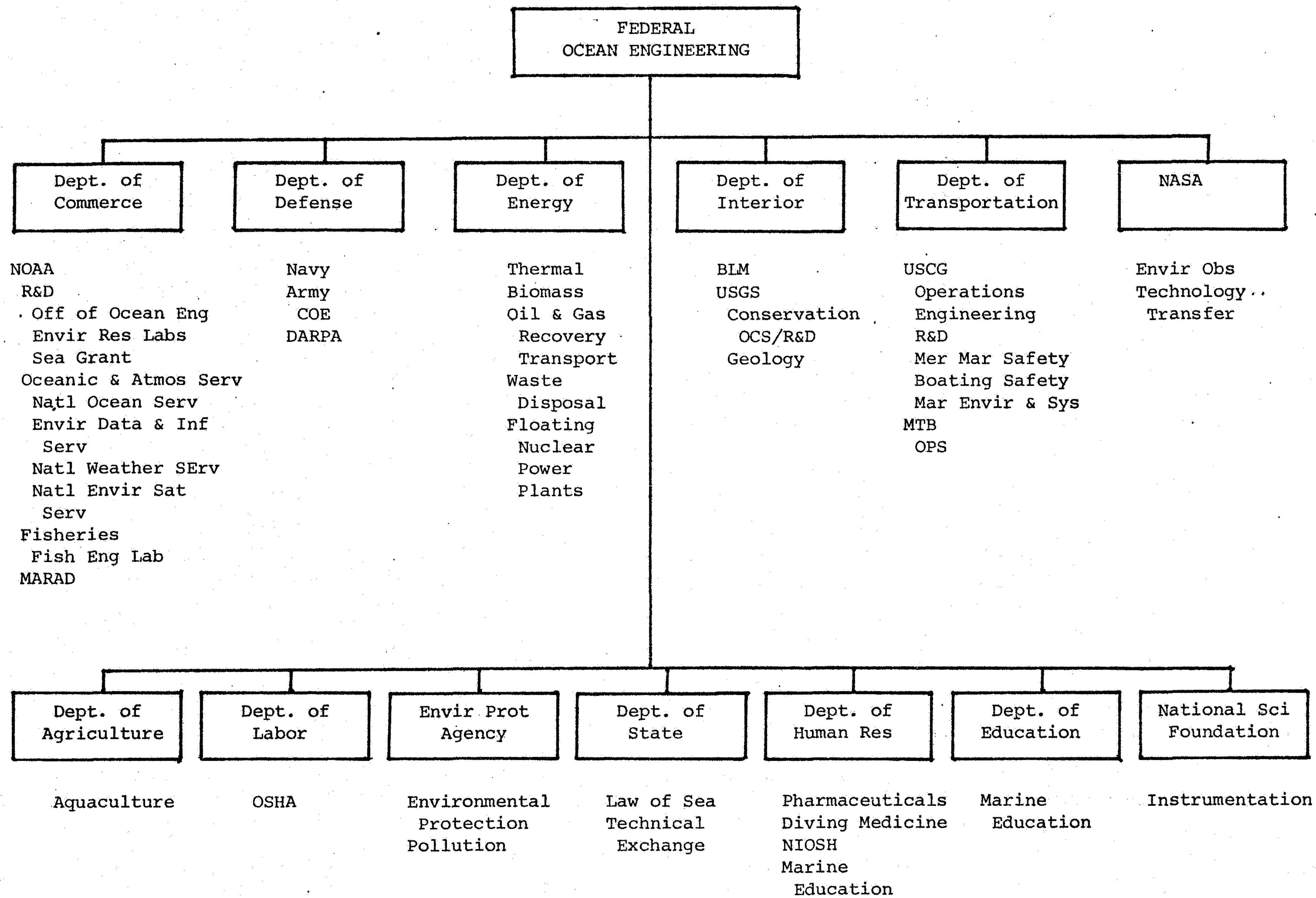

Figure 1 Federal Activities Involved in Marine Research Activities (from the Marine Board, National Research Council; Naval Ocean Systems Center)

and/or "defining" the marine environment. In this respect the requirements are not expressed in terms of technology needs, but are expressed in terms of data requirements in the areas of biology, geology/geophysics, chemistry, physics and meteorology.

The NACOA report, referenced above, was the only report reviewed which specifically and solely attempted to: 1) survey the national civilian needs in ocean engineering; 2) defined specific applications which should be undertaken; 3) suggested the relative roles of government and industry; and 4) recommended how government efforts might be otherwise applied.

The findings of this report are again quoted, in that, they reflect the present status of Federal Government marine technology programs:

"a) We (NACOA) found no consensus or major imperatives.
b) The panel was not offered priorities, but selection schemes to find them.
c) The common trend did not turn out to be a specific high priority application. Instead it was the apparent inability to choose what ought to be done first.
d) It was also evident that there is no natural government sponsor for the general support of civilian ocean engineering needs. Of the government agencies with direct interest in the oceans, only the Navy has responsibility for pursuing advanced technology directly; other agencies, such as the Department of Interior, NOAA, the Coast Guard, etc. relate the ocean engineering needs to their service requirements and so no one has a broad oversight."

These findings and conclusions are, after six years, still applicable to the Federal civil ocean community. Consequently, it is virtually impossible to identify "key" programs and, therefore, even more impossible to designate programs having priorities over other programs. Additionally, a variety of on-going efforts are not programs per se, but are tasks being conducted under an overall mandate (e.g., Environmental Protection Agency's ocean monitoring tasks); consequently, there are not identifiable as "programs".

In view of the foregoing, the following tabulation presents the various programs or projects now underway at the various activities under which they are listed. Beneath each program/ project title are various technological needs or current programs revealed during the interviews and literature reviews.

DEPARTMENT OF COMMERCE (DOC)

National Oceanic and Atmospheric Administration (NOAA), National Data Buoy Office (NDBO) (10)[1]

Concerned with development of moored, deep ocean buoy systems to monitor a variety of sea water and climatological properties. The following represents current research and development needs:

- Develop reliable power system, minimize size and weight, reduce maintenance and life cycle costs.
- Investigate alternate power sources (now use carbon-zinc primary batteries) such as: solar cells, fuel cells and lithium batteries.
- Develop remote command/interrogate communications between National Space Technology Laboratory (NSTL) and remote stations via National Environmental Satellite Services (NESS).
- Investigate random reporting techniques using Geostationary Operational Environmental Satellite (GOES) system.

NOAA, Office of Marine Technology, National Ocean Survey (NOS) (9)

Provides instrumentation research and development to support the NOAA surveying fleet. The following are the areas where current efforts are underway.

- Development of method for remote current measurements.
- Utilization of radar measurements of surface currents and waves to determine wave/current intensity and predictability.
- Development of measurement techniques (real-time or in situ) for determining sea water pollution characteristics.
- Development of global positioning system to provide geodetic accuracy of ± 1m. (Being developed by the Navy, will be integrated onto NOS vessels.)
- Utilization of lasers for bathymetric charting. (Joint development effort between Defense Mapping Agency and NOS.)

NOAA, Ocean Dumping and Monitoring Division (ODMB) (7)

ODMB has been mandated to carry out monitoring and research on the effects of ocean dumping to provide essential technical assistance to the Environmental Protection Agency (EPA) and to the Army Corps of Engineering (COE) in their permit review and dumpsite evaluation programs. The following are areas where research and development are needed:

- Most pressing need is to acquire chemical and biological sensors to measure temporal and spatial variability of various natural and introduced water properties.

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[1] Number within parentheses identifies Program Manager listed in Appendix A.

- Need development of technique to measure suspension of materials in water.
- Develop techniques for surveying, containment, emplacement/ retrieval and long-term monitoring of radioactive wastes.

NOAA, Sea Floor Engineering (1)

Overall goal is to develop techniques to improve mapping, sampling, and geotechnical measurements of the sea floor. The following recommendations for research and development were made. Those recommendations where work is being conducted are noted as "active".

- Sequential, near-continuous sampling and constituent analysis of surficial sediments. (Active)
- Reliable instruments required for storm measurements. (Active)
- Improved undisturbed core sampling.
- Improved high and low pressure piezometers. (Active)
- Better sediment movement monitoring equipment.
- Refinements in data acquisition.
- Storage and processing sediments under field conditions.
- In-hole pressure meters.
- Pore pressure measurements.
- Measurement of pore pressures under dynamic loading. (Active)
- Require development of instruments to measure (in situ): (Active)
  - State of stress.
  - Gas content and phase.
  - Density (unit weight).
- Uncertainty in relating various in situ measurements to construction requirements.
- Capability to detect, delineate and roughly measure engineering properties of soft layer under sand layers.
- Capability to rapidly classify sediments over an area or along a route.
- Slope stability measurements need:
  - Reliable, accurate long-term creep inclinometer type sensors.
  - Instruments for measuring sediment movement rate. (Active)
  - Deep (up to 300 ft penetration) soil movement measurements. (Active)
  - In situ stress measurements, especially lateral stresses (dynamic and static).
  - In situ permeability, including anisotropy.
  - In situ shear strength. (Active)
  - Acoustic instruments to delineate major slump blocks and minor slump features.
  - In situ probe to measure sand density up to 15m depth.

In situ liquefaction test (general and localized).
Offshore measurement of microseismic activity. (Active)
Measurement of fossil permafrost in sea floor sediments.
Measurement of pore water electrolyte.

- Techniques required for identifying and evaluating the magnitude of probable sea floor fault movement, frequencies and total displacement.
- Development of digital side scanning sonar. (Active)
- Predict performance of laterally loaded piles. (Active)
- Develop standard data format and data transfer/retrieval and information management system.
- Develop probabilistic/reliability analysis for optimum risk reduction in offshore geotechnology.

DEPARTMENT OF INTERIOR (DOI)

U.S. Geological Survey (USGS), Conservation Division (19)

The USGS has regulatory responsibility for activities which affect safety and pollution-prevention in marine oil and gas operations on the Outer Continental Shelf (OCS). USGS field personnel monitor industrial practices and identify technologies where research and development might reduce the likelihood of accidents and pollution. To this end, a contract research and development program was established as an integral part of the USGS marine oil and gas operations. The program involves both field and headquarters operations personnel who perform technical assessments and review technical proposals and program accomplishments. It consists of research, development and evaluation, basically in the field of technology. Though some projects involve the fabrication of hardware, such equipment is for purposes of modeling to prove-out the technology. Research is accomplished by contracts at universities, private industry, and through funding at Government laboratories. The following technological research and development projects are now being conducted:

- Determine the feasibility and practicality of using ultrasonic flow measuring techniques to minimize oil spills from offshore oil lines.
- Determination of dynamic design criteria for offshore structures.
- Detection of incipient crack formation in offshore structures by internal function monitoring.
- Detection of incipient structural failure by the Random Decrement method.
- Utilization of cavitation phenomena for structure cleaning.
- Investigation of methods to achieve significant localized wave attenuation in the open ocean.

- Development of Remotely Operated Vehicles for structure/ pipeline inspection utilizing fiber optics and thru-water acoustic telemetry techniques.
- Determine the applicability of pattern recognition technologies for underwater optical imaging in turbid coastal waters.
- Development of improved blowout prevention procedures for deep-water drilling operations.
- Investigate the feasibility of applying fluidics technology to down-hole data telemetry without interruption of drilling operations.

USGS, Hazards Studies (Office of Marine Geology) (16)

Conducts regional survey of Outer Continental Shelf to determine geological framework. Data used to establish 5 year lease sales. Data also used in Bureau of Land Management environmental impact studies. Environmentally looking for geology on sea floor which might cause problems (i.e., mud slides, faults, gas pockets, etc.) so that no platforms/well will be placed thereupon. The following is an area where technological improvements are required.

- Need development of deep ocean mapping/surveying instrumentation (instrumentation now being used was designed for shallow water application).

DEPARTMENT OF TRANSPORTATION (DOT)

U.S. Coast Guard (USCG), Pollution Surveillance and Monitoring (Aerial Pollution Survey Program) (22)

Conducts surveillance and other appropriate enforcement activity to prevent unlawful transportation of material for dumping or unlawful dumping. The following areas are those requiring research and development.

- Quantification sensor to identify type of oil spill and quantity.
- Hazardous substance detector to identify oil that has sunk or is suspended in water column.
- Improved data link monitor to Coast Guard Station.
- Improved battery power for in situ monitoring device. (Solar power utilization is being investigated.)

USCG, Pollution Response Program (20)

Responsible for removal of coastal and open water oil and chemical spills. Using the criteria that: 1) the technology is not readily available; and 2) that it is too expensive for private industry development, this program is engaged in the following projects:

- Improvement of oil skimmers in open waters.
- Development of oil skimmers in currents over 1.5 knots.
- Development of self-propelled oil skimmers capable of 8 knots.
- To develop techniques for assessing the pollution danger from handicapped vessels, restraining the flow of pollutants from them, and designing salvage techniques.

DEPARTMENT OF DEFENSE (DOD)

Office of Naval Research (ONR), Ocean Science Programs (12)

Conducts basic research into ocean properties which bear on the effective employment of offensive/defensive weapons systems. The following projects are now underway.

- Evaluate commercial and develop improved acoustic doppler logs.
- Evaluate/develop radar backscatter techniques.
- Evaluate and develop towed body with EM log for current at single shallow depth.
- Evaluate and develop tow body with Conductivity/Temperature/Depth (CTD) and acoustic log/density and current of varying depth.
- Evaluate tow body with turbulence sensors/turbulence (temperature, conductivity, velocity) at varying depths.
- Develop and evaluate electro-magnetic techniques.
- Evaluate commercial Expendable Sound Velocity/Temperature (XSVT) and XCTD.
- Evaluate commercial Fine Structure Expendable Bathythermagraph (FSXBT) temperature fine structure profiling.
- Develop and evaluate turbulence sensors-techniques.
- Develop generalized recorder-processor-display unit for expendables.
- Future developments (not presently under investigation):
    - initiate work to support downhole data gathering (e.g., long period seismometer/tiltmeter).
    - address material performance in sub-surface assemblies from corrosion and structural standpoints.
    - develop unmanned Arctic ice penetration capabilities.
    - initiate work to address complex sampling problem of benthic boundary layer dynamics.

DEPARTMENT OF ENERGY (DOE)

Offshore Thermal Energy Conversion (OTEC), Ocean Systems Branch (14)

OTEC is concerned with extraction of thermal gradient, wave and current energy from the sea. The following is a listing of projects in support of the overall OTEC program. The status of the project is noted following each entry.

- Define impact of biofouling and corrosion on system performance. (Planned)
- Relative to environmental impacts, define: currents, temperatures, oxygen content, pH, salinity gradients on an engineering and environmental basis. (Active)
- Evaluate and test candidate cold water pipe materials in terms of: (Active - all aspects)
  - Hydrodynamic load definition.
  - Deployment/Recovery/Survival Techniques.
  - Platform attachments and pipe joints.
  - Structural analysis of pipe and platform.
  - Special material characteristics.
  - Constructability.
  - Operation and maintainability.
  - Integration with other OTEC subsystems.
- Design, construct and test a 125 kW turbo-generator system for wave energy conversion. (Active)
- Demonstrate technical feasibility of drouge-chute type model ocean energy conversion system. (Active)
- Empirically analyze Scripps-For wave pump. (Active)
- Determine feasibility of converting ocean wave energy into electrical energy using an electrochemical hydrogen gas concentration cell with a protonic conductor. (Active)
- Preliminary design study of conversion device, the turbogenerator element of a pneumatic type (Masuda) wave energy conversion system. (Active)
- Assess wave energy resources by means of a spectral ocean waves model. (Active)
- Investigate the synchronized restraint/release semi-constrained spartype buoy in application of wave energy conversion. (Active)
- Assess performance of a wave energy conversion buoy. (Active)
- Study the technical potential of three wave energy conversion systems. (Active)
- Perform: (Active - all aspects)
  - an analytical study of the hydro-elastic stability of ocean turbine rotor blades.
  - an experimental study of the hydro-elastic stability of a scale model ocean turbine.
  - an analytical study of the mooring and anchoring system of an ocean turbine.
- Conduct bottom assessment for anchor and cable studies. (Planned)

Division of Waste Isolation (15)

The ultimate objective of this group's program involves the disposal of nuclear wastes (low and high level) in the deep sea (greater than 4,000m depth). Near term objectives are to collect sufficient data to assess the technical and environmental feasibility of the deep sea floor as a receptacle for nuclear wastes. Ultimately, the goal is to develop and maintain disposal sites for use by the United States and other nations.

At this point (the program has been underway since 1974) the program is still looking at the feasibility of the ocean sediments acting as an isolation barrier. Concurrently, potential sites are being studied in terms of water column composition (chemical, biological components), as well as bottom sediment geotechnical properties, constituents and stability.

Subsequent research and development steps in this program are dependent upon the outcome of the feasibility studies. One method of placing high level wastes into the sub-sea floor is by drilling. The engineering feasibility of this technique has been adequately demonstrated by vessels such as GLOMAR EXPLORER. Further engineering research and development will await the outcome of environmental feasibility. The program is wide ranging in scope and will eventually consider the development of waste transport to the port of embarkation, loading and ship transport to the dump site area(s).

Under the present organization, Sandia Laboratories provides technical direction and sub-contracts to oceanographic institutions and academic institutions to carry out research. A technical steering committee guides the project and consists of representatives from DOE; Scripps Institution of Oceanography, Woods Hole Oceanographic Institution, University of Oregon and Sandia. Key activities and their respective roles are:

- Woods Hole Oceanographic Institution and Lamont Dougherty - investigations into marine geology to determine what formations are barriers to nuclear waste.
- Oregon State University - investigation of physical and chemical properties of potential site sediments.
- Scripps Institution of Oceanography - investigate characteristics of benthic organisms.
- Sandia Laboratories - provide technical direction and develop methematical predictive models. Also looking into heat transfer characteristics and metallurgy (containers).

ENVIRONMENTAL PROTECTION AGENCY (EPA)

Oceans Program Branch (23)

Responsible for coordinating environmental aspects of ocean activities (OCS oil and gas and deep sea mining) within EPA excluding the areas of spills and dumping. The following area requires research and development.

- Development of sensor alarm system to monitor water column parameters during oil and gas exploratory drilling.

NATIONAL ACADEMY OF ENGINEERING (NAE)

Sea Floor Mining Needs (37)

The following areas were recommended for research and development.

- Improve understanding of fatigue of material in sea water (pipe and pipe handling equipment).
- Improve understanding of fracture mechanics of material exposed to sea water.
- Improve understanding of effects of residual stresses due to welding.
- Improved instruments for rapid, wide area surveys and sampling (mineralogy, topography, geophysics, geology).
- Development of in situ constituent analysis device. (Work underway at University of Georgia.)
- Development of automatic device to scan a TV screen (i.e., signal) to conduct manganese module census.

Offshore Structure Inspection/Monitoring Needs (37)

The following recommendations for research and development were made. Those recommendations where work is being conducted are noted as "active".

Cleaning

Adapt the present Navy Work Systems Package for deep cleaning operations for commercial application by divers and submersibles. (Planned)

Remote Sensing Devices

Television: Investigate the use of fiber optics cables and transmission and signal processing techniques to meet the bandwidth requirements of remote underwater TV transmission for inspection purposes. (Active)

Optical Scan: Develop a systems concept to exploit laboratory developments in rapid total scanning (laser mapping) of underwater structures.

Acoustic Scan: Exploit acoustic imaging technology to cope with regimes of high turbidity and consequent limited visibility. (Planned)

Ultrasonic Thickness Gauge: Develop an instrument designed specifically for underwater use. (Active)

Radiographic: Adapt existing instruments for use in unmanned submersibles. Eliminate radiation hazard to observers. (Active)

Magnetic Particle Inspection (MPI): Develop MPI systems for tethered and untethered submersibles; extend depth capability beyond present 100m limit.

Corrosion Potential Meters: Package for use in unmanned submersibles. (Accomplished)

Sub-Bottom Profilers: Experiment to determine profilers' applicability for use in inspection of buried man-made structures such as platform foundations.

Profile Gauge: Package for use with remote controlled vehicles. (Active)

Accelerometers (Dynamic Analysis): Pursue and develop this technology. (Active)

Ultrasonic Flaw Detection: Develop computer-aided processors for in situ or real time interpretation.

Inspection Vehicles

Divers: Extend depth capability of commercially available saturated diving services. Adapt fiber optics to diver-carried data tethers to improve safety, to obtain greater transmission bandwidth and immunity from electromagnetic interference.

One-atmosphere Diving Suits (ADS): Improve tactile response of ADS, improve manipulators and include snap-on-tool capability; improve operator response in reduced visibility conditions.

Manned Submersibles: Develop lightweight, expendable fiber optics links for communication and data transmission including observing underwater inspection from the surface.

Unmanned Tethered Submersibles: Develop lightweight cables for fiber optics and power transmission (high data-rate feedback). (Active). Develop "intelligent" vehicles with minimum of operator feedback control required.

Unmanned Untethered Submersibles: This embryonic technology area should be supported and systems development encouraged. (Active)

Pipeline Inspection and Monitoring

- Develop devices for the measurement of internal corrosion in underwater platform risers. (Active)
- Develop leak detection flow meters. (Active)

NATIONAL SCIENCE FOUNDATION (NSF)

NSF is an agency of the Federal Government which promotes and advances scientific progress in the United States by sponsoring scientific research and encouraging and supporting improvements in science education. The Foundation does not itself conduct laboratory research. Recipients of NSF funds are responsible for the conduct of their projects or activities and for the results produced. In judging proposals, NSF relies heavily upon the advice and assistance of advisory committees, outside reviewers and other experts (e.g., Peer Review Groups). In some areas, Applied Geophysical Sciences for example, the objective is also to increase technological innovations growing out of discoveries made during the basic research phase.

Oceanographic Facilities and Support Branch (28)

In regard to ships operated by NSF, the following needs are evident.

- Develop winch capabilities to handle 10,000m of 5/16 in. e-m cable.
- Improve understanding of ship's motion effects on loading stress of wire rope and cables. (Being investigated by Woods Hole Oceanographic Institution)
- Develop monitoring system for winch (TV cameras or electronic sensors).
- Improve specialized e-m cable to meet dynamic and corrosive requirements.
- Improve automatic data logging techniques.
- Develop electronic interfacing of shipboard positioning system to a common ship parameter network.
- Develop automatic input of ship speed and heading into Satellite Navigation (SATNAV) units.
- Develop technique to obtain SATNAV position regardless of satellite position.
- Reduce interference on HF/SSB voice channels.
- Improve dual yagi shipboard satellite antenna systems.
- Explore feasibility of future satellite communications system (i.e., Maritime Satellite "MARISAT").

Division of Polar Programs and Division of Ocean Sciences (31)

Support basic research in the Arctic and Antarctic concerning geology, biology, glaciology, meteorology and oceanography. The following areas were identified as needing research and development.

- Need "conditional sampling" device either remotely controlled or preprogrammed to record data in response to events which are not continuous.

- Satellite communications needed to obtain data dumps from unmanned sensor systems.
- Need development of color scanner for sea surface plankton assay.

International Decade of Ocean Exploration (IDOE) (33)

Presently involved in measurement of ocean processes for improved environmental forecasting. Future programs include coastal ocean dynamics, Pacific equatorial current dynamics and large scale circulation studies of the Western Atlantic. The following area was identified as requiring research and development.

- Need remote sensing device for measuring surface wind stress.

U.S. CONGRESS

Office of Technology Assessment (OTA), Oceans Program (35)

Presently engaged in a Ocean Research Technology project. Purpose is to determine national capabilities currently available (hardware, equipment, etc.) and how they relate to present and future needs across all governmental agencies, especially those needs that result from legislative action. Five areas being addressed are:

- Pollution
- Oil and Gas (other minerals)
- Weather and Climate
- Fisheries
- Basic Research

The foregoing represents current technological improvements and developments recommended during the personal interviews and literature reviews. It is emphasized that the interviews represent input only from the metropolitan Washington area. There are numerous regional offices and activities within these agencies that have not been contacted and, undoubtedly, have requirements in addition to those listed above.

AGENCY CAPABILITIES FOR ADDRESSING TECHNOLOGICAL NEEDS

A variety of sources are employed to conduct research and development to satisfy Federal government needs. These sources are in-house laboratories, academic institutions, non-profit organizations and private contractors. At any specific time an agency might employ one or all of these sources.

In some instances, the requiring activity has neither an in-house capability or funds to conduct R&D outside. The National Academy of Engineering, for example, is concerned with identifying technological gaps in certain ocean endeavors. Its recommendations may or may not lead to developmental action, if it does, then the actual work is conducted by other activities and is under the aegis of other activities also.

The procedure for selecting and/or contracting with an outside activity varies from agency to agency. The Office of Naval Research, for example, has for many years dealt with several academic institutions whereby ONR's funding and interest has created small centers of excellence in a particular subject. Once these areas of expertise have been developed, their existence has continued owing to the interest and talents of a principal investigator and his graduate students to pursue work in the particular area. The Marine Physics Laboratory of Scripps (MPL) is one example. Over ten years ago MPL, under the direction of Dr. Fred Speiss, began work on the towed sensor system DEEP TOW. This work has continued for over a decade with grants from both the Navy and National Science Foundation.

Some agencies, lacking an R&D facility, contract the work out to other government agencies. The present National Oceanic and Atmospheric Administration's, Office of Ocean Engineering's work on the riser components of OTEC is such an example. This work is conducted by NOAA on a reimbursable basis for the Department of Energy. Interestingly, NOAA itself does not do the actual R&D, it, in turn, contracts out to a non-government facility and acts as contract monitor.

The Universities are a special and unique category within the Federal ocean R&D community. Because the ocean community is small and because of specialization, the Universities enjoy the best of both worlds. For example, the recent NOAA and National Academy of Engineering recommendations for National needs in sea floor engineering were obtained from panel members of high esteen in this field. Many of the recommendations are, essentially, the next logical step in the panel member's present or desired R&D program at his or her academic institution. Since the results of the panel's deliberations can be used, and rightfully so, to justify work in a particular area, a government agency with funds and interest in the particular area has not only a mandate, but a party more than willing to carry out that mandate.

The following narrative identifies in-house and outside R&D capabilities for various Federal Agencies. Since this is a surficial look at the field at large, only a few of the outside contractors are presented.

DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

NOAA's marine research and development requirements are conducted in-house and outside. There are four major research and development activities within NOAA; these are identified below. Where appropriate the non-NOAA organizations which are now conducting and have recently conducted work under contract are specified. (Only hardware development, not studies, are included.)

Office of Marine Technology, Rockville, MD
- Test and Evaluation Laboratory, Washington Navy Yard, Washington, DC
- Engineering Development Laboratory, Riverside, MD

Office of Ocean Engineering, Rockville MD
- Manned Undersea Science and Technology Office, Rockville, MD
- Ocean Instrumentation and Engineering Office, Rockville, MD
- National Data Buoy Office, Bay St. Louis, MS
- Non-NOAA contractors include: Lehigh University, Jet Propulsion Laboratory, University of Georgia

Fisheries Research Laboratory, Bay St. Louis, MS

Environmental Research Laboratory, Boulder, CO

Within the Environmental Research Laboratory are regional activities, such as the Pacific Marine Laboratory, the Atlantic Marine Laboratory, the Atlantic Oceanographic and Meterological Laboratory, which conduct research and development both in-house and outside. A great deal of the engineering work they perform is of such a nature that it does not require high technology and can be performed in-house with minimal effort and funding. However, in some instances these regional activities do contract with outside sources.

DEPARTMENT OF DEFENSE (Navy)
Office of Naval Research

Research and Development requirements for ocean science in ONR are satisfied both in-house and outside. The Navy has developed a wide-ranging inventory of laboratories to deal with virtually any problem it encounters. The Naval Ocean Systems Center (NOSC), the Naval Civil Engineering Laboratory (NCEL), the Naval Research Laboratory (NRL) are only a few of the activities under direct

Navy control which can be - and are - brought to bear on specific problems. Academic institutions abound which rely upon Navy funds for on-going R&D projects. A sampling of current academic institutions involved in ocean science engineering developments are: Scripps Institute of Oceanography, Stanford University, Texas A&M University, University of Washington (Applied Physics Laboratory), Oregon State University, the University of British Columbia and Woods Hole Oceanographic Institution. In diving technology the University of Pennsylvania and Duke University are recipients of Navy funding.

Unlike most civil government activities involved in ocean research, the Navy has had an historic involvement with the ocean. Consequently, it has built up an inventory of "captive labs" which are quite capable of addressing virtually any technical research and development program worthwhile funding.

DEPARTMENT OF THE INTERIOR

U.S. Geological Survey

The Geological Survey is a relative newcomer to ocean-oriented R&D. Of the programs identified, only the Branch of Mining, Oil and Gas Operations is actively engaged in R&D. Their interest stems from a USGS mandate to provide inspection/testing criteria for structures on the U.S. Outer Continental Shelf. The philosophical arguement, in part, for USGS research and development programs in the area of inspecting of offshore structures, is that, if they can demonstrate that technology exists whereby certain forms of inspection or monitoring can be conducted, then it is not unreasonable to ask the offshore operator to conduct such investigations on his platform.

USGS employs the Federal government, industry and academia in its R&D programs. As far as is known, no in-house R&D is conducted. The following is a listing of current programs and the sources being used to conduct them:

<u>Remote Operated Vehicle development</u>: Naval Ocean Systems Center and the University of New Hampshire
<u>Vibration Monitoring development</u>: Massachusetts Institute of Technology
<u>Structural Cleaning Using Cavitation Phenomena</u>: Daedalean Associates

DEPARTMENT OF ENERGY

DOE does not have in-house marine technology research and development capabilities. All such work is performed by outside activities representing a variety of interests. The majority of DOE's R&D is conducted by Government Owned-Contractor Operated Laboratories. These include:

- Lawrence Berkeley Laboratory, Berkeley, CA
Sandia Laboratories, Albuquerque, NM
Lawrence Livermore Laboratory, Livermore, CA
Argonne National Laboratory, Chicago, IL
Brookhaven National Laboratory, Brookhaven, Long Island, NY
Oak Ridge National Laboratory, Oak Ridge, TN

In two of the above Laboratories (Berkeley and Argonne) small groups of expertise have been formed to work on various marine problems of limited scope.

The bulk, if not all, of DOE's marine technology R&D is concerned with utilization of the ocean's inherent power sources: waves, currents, thermal gradients. To conduct this work DOE is using Federal government facilities (NOAA/OOE); Academic institutions (University of California, Temple University, City College of New York, Massachusetts Institute of Technology), and a variety of small and large industrial organizations.

DEPARTMENT OF TRANSPORTATION
U.S. Coast Guard

The Coast Guard has a Research and Development Center in Groton, Connecticut. The primary function this center serves is to monitor R&D contracts. It has, according to Capt. T. Lutton, Coast Guard R&D Office, very little hands-on capability to conduct its own research and development. A substantial portion of Coast Guard R&D is performed by other government activities possessing similar interests and the technical capability. In many instances this turns out to be Navy activities. By taking this approach the contracting problems (as opposed to advertising and negotiating with a private concern) are considerably reduced, and it conforms with present guidelines that encourage cooperative programs with other Federal agencies.

The Coast Guard also funds the academic community for R&D programs. Certain institutions have been designated as leaders in a particular area of technological research. When their research coincides with Coast Guard interest a grant is established to continue the work or slant it in a direction meeting Coast Guard needs. Private industry is also used by the Coast Guard, but less so than government and academia.

NATIONAL SCIENCE FOUNDATION

NSF has no in-house R&D capability. All on-hands work is accomplished by one or several of the academic institutions involved in NSF programs.

COMMONALITY OF TECHNOLOGICAL NEEDS - PRESENT AND FUTURE

PRESENT

The wide variety of Federal ocean programs produces a diversity of technological needs. In most instances the requirements for a specific piece of hardware or a specific instrument will have application only to the particular program responsible for its development. However, the function it is serving or the environmental characteristic it is measuring can be of mutual interest to different agencies. There is, therefore, a commonality in purpose but not in specifics. The following tabulations identify those projects in which such commonality exists:

Materials:

- ONR - address material performance in sub-surface assemblies from corrosion and structural standpoints.
- NAE - improve understanding of material fatigue (pipe and pipe handling equipment) and fracture mechanics of material exposed to sea water.

Inspection/Monitoring:

- USGS - develop vibration analysis techniques for monitoring structural failures.
- NAE - pursue and develop technology related to dynamic analysis (i.e., vibration) utilizing accelerometers.

Data Acquisition:

- NSF - satellite communications are required to obtain data dumps from unmanned sensor systems.
- NDBO - develop remote command/interrogate communications between NSTL and remote stations.

Underway Sampling:

- ONR; NOAA; NAE - improve and develop devices and techniques in the areas of: towing/hydromechanics, sampling and flux measurements/analysis.

Current Measurements:

ONR

- evaluate commerical and develop improved acoustic doppler logs for current profiling.
- evaluate and develop radar backscatter techniques for current profiling.
- evaluate and develop towed body with EM log for current measurements at simple shallow depth.

NOAA

- develop remote methods of current measurements.
- utilize radar measurements of surface currents to determine intensity and predictability.

Wave/Wind Stress Measurements:

NOAA - utilization of radar measurements of waves to determine wave intensity and predictability.

NSF - develop a remote sensing device for measuring surface wind stress.

Laser Application:

NAE - develop a systems concept to exploit laboratory developments in rapid total scanning (laser mapping) of underwater structures.

NOAA - development of bathymetric mapping device utilizing laser technology.

Mapping/Surveying:

NOAA, USGS, NAE - require improvements in present instrumentation and/or development of new techniques for deep ocean bottom mapping/surveying in terms of: greater resolution of details; sediment classification over large areas; delineation of slump features and faults; and manganese nodule quanitification using remote TV.

Pollutants:

USCG

- quantification sensor to identify type and quantity of oil spill.
- hazardous substance detector to identify oil which has sunk or is suspended in the water column.

NOAA - develop techniques for long term monitoring of radioactive and other wastes.

EPA - develop techniques to monitor water column characteristics during oil and gas exploratory drilling phase.

A broader commonality can be observed from a matrix of Federal Agencies vs Missions (or area of interest) as shown in Figure 2. Here, the common areas of interest (within which each Agency has defined specific and virtually exclusive objectives) can readily be seen. By developing this matrix further, a commonality in various technology developments can be shown as in Figure 3. (An explanation of the headings under Technical Problems is contained in Appendix C.) In order of decreasing priority, the commonality between mission and technical needs is as follows:

Surveying/Mapping Instrumentation
In Situ (Long term) Instrumentation
Undersea Vehicles Capabilities
Structural NDT
Data Acquisition/Processing/Logging
Materials Research
Water Column Measurements
Bottom Sampling Devices
Sub-bottom Measurements
Power Sources
In Situ (Short term) Instrumentation

Missions \ Federal Agencies	DOC (Commerce)	DOE (Energy)	DOI (Interior)	DOT (Transportation)	EPA (Environment)	NSF (Science)	NAS (Engineering)	ONR (Navy Research)
Waste Disposal	●	●		●	●			
Resource Exploration	●	●	●		●		●	
Resource Exploitation	●	●	●		●		●	
Oil and Gas		●	●	●	●		●	
Fisheries	●			●				
Mining	●		●	●			●	
Energy from the Sea	●	●		●			●	
Navigation/Communications	●		●	●			●	
Environmental Prediction	●	●	●	●		●		●
Environmental Protection	●	●	●	●	●			
Salvage				●	●			
Ocean Science	●					●		●
Sea Floor Engineering	●					●	●	

FIGURE 2 FEDERAL AGENCIES VS MISSIONS (i.e., areas of interest)

Technical Needs / Missions	Instrumentation																				
						Sampling															
	Underway	Towed	Expendable	In Situ (Short Term)	In Situ (Long Term)	Water	Bottom	Boundary Layer	Sub-bottom	Structural NDT	Survey/Mapping	Airborne/Remote	Data Acquisition, Processing, Logging	Communications	Navigation/Positioning	Materials	Power Sources	Sea Power Utilization	Equipment (Shipboard)	Mooring/Anchorage	Undersea Vehicle Capabilities
Waste Disposal					•	•					•					•					
Resource Exploration					•						•										•
Resource Exploitation										•											
Oil and Gas					•	•				•	•										•
Fisheries											•										•
Mining				•						•	•		•			•					
Energy from the Sea										•						•	•	•		•	
Navigation/Communication																					•
Environmental Prediction							•		•		•		•								
Environmental Protection					•	•	•		•	•	•		•				•				•
Salvage																					•
Ocean Science	•	•	•		•	•		•				•	•	•	•	•			•		
Sea Floor Engineering				•	•		•		•		•		•								

FIGURE 3 MISSIONS VS SPECIFIED TECHNICAL NEEDS

FUTURE

In view of the fact that there are few present programs which indicate a commonality in technological needs, it would seem presumptous to discuss future commonality. Particularly since there is no indication that the various Federal ocean programs will receive any more centralized coordination or unified direction in the future than they have in the past. Nonetheless, the programs so far identified and trends apparent in the overall ocean community, indicate areas where future technological research and development will concentrate as the need arises (or, as so succinctly stated in the 1974 NACOA report "...until we hit a snag...".

The future (in this case the decade of the 1980s) use of the oceans will concentrate in several areas: energy (i.e., oil and gas); pollution; science and mining. These areas preclude military interests, surface transportation and recreation, and are not necessarily in order of importance. The following discussion attempts to project the major technological needs these areas will tend towards in the 1980s. These needs are in respect to Federal government programs and interests; not private industry's, although the two are common in several areas.

ENERGY

Offshore oil and gas exploration has progressed into deeper and more hostile waters. In the 1960s the deepest well was 192m. By the close of the 1970s, an exploratory well off Africa was drilled in 1,200m of water. Current drilling in the Davis Strait and offshore of Canada's east coast is in 1,615m of water. The 1960s offshore drilling was in relatively calm and warm waters: offshore California and the Gulf Coast. In the '70s it moved to more hostile waters: North Sea, Gulf of Alaska, Northeast U.S. As petroleum prices escalate, the economics of oil and gas extraction from deeper and more hostile waters becomes more favorable, and there is no indication that oil and gas prices will decline.

By 1980 more than 22,400 wells were drilled in U.S. waters alone and over 7,000 miles of underwater pipelines has been laid. Wells have been drilled in the waters of at least 90 countries and oil is being produced offshore in at least 30 of these countries. In 1977 offshore areas accounted for about 16 percent of world wide crude oil production (10 million barrels daily). According to the Exxon Corporation, the offshore crude oil reserves are estimated at 26 percent of the world total (170 billion barrels). There is every reason, therefore, to assume that offshore oil production and exploration will continue to increase at an ever-expanding rate and into deeper waters. In some areas, such as Alaska, Canada and the high latitudes of the North Sea, this work may take place in areas where an ice cap will be present at least some portion of the year and, perhaps, permanently.

- Deep sea drilling to depths of 2,000m is now within reach, major breakthroughs are not required to meet this goal, only modifications to present techniques. There are, however, a variety of problems which accompany deep water oil extraction. Not only are there problems which will occur in the exploration phase, but in the development and production phases as well. The Federal government's interest in these problems is both direct (the national need for a self-sufficient domestic energy supply) and indirect (environmental, resource mapping, platform/pipelines certification, etc.)

The major source of problems within the offshore oil industry will be derived primarily from increased depth and secondarily from ice. The deepest working dive to date has been 457m, beyond this depth the diver cannot be employed and total reliance must be placed on mechanical means of manipulation. Attending this increased depth are instrumentation/performance problems; these will be discussed below. By introducing an ice cap virtually all conventional means of support services for oil and gas are negated by the simple fact that surface ships and platforms, the workhorses of offshore energy, are no longer applicable for part or all of the year. If production does become economically feasible under-ice, then major technological breakthroughs are required by the operators and the Federal government. It is beyond the scope of this study to identify all areas where problems will occur, consequently, the following areas are only the most prominent ones which will occur with respect to sub-surface endeavors.

Resource Assessment (Pre-Exploration Phase)

The Federal government's interest in this phase is twofold: 1) to estimate the resources of a particular area prior to leasing; and 2) to gain an appreciation for the potential hazards (e.g., slumping, faulting, erosional processes, explosive ordinance, etc.) which may jeopardize safe operations.

The first of these interests should not be seriously hindered by increased depth since the explorations which are undertaken (seismic, gravimetric, magnetic) have already been used satisfactorily in 2,000m. Ice is a different problem since it precludes the normal use of surface vessels.

The hazards surveys undertaken by USGS have been identified earlier. The need expressed is for instrumentation, mainly acoustic, which is designed for use in greater depths, as opposed to the 300 or so meters which are now being investigated. These surveys attempt, among other goals, to estimate the sediment or sea floor potential for failure. In this instance virtually all the problems identified under sea floor engineering exert an influence on the ability to ascertain present conditions and predict the sediment response to platform/pipeline installation.

As with geophysical explorations, surface ships are the primary platforms for conducting these surveys, if ice is a factor the survey will be slowed or aborted accordingly.

Exploration Phase

During the exploration phase various drilling platforms are employed to locate economical reservoirs. This phase is preceeded by intensive remote means, such as seismic, gravity and magnetic surveys, to specify the most promising drilling sites.

Federal government interests in this phase are limited primarily to the possible environmental effects of blowouts. The recent Petrolos Mexicanos' blowout of Ixtoc-1, although a developmental well, is an example of this type of failure. Although Ixtoc-1 was only in 45m of water, the blowout, which occured on 3 June 1979, was only brought under control in late 1979. A variety of means were employed to assess the damage and control the flow. These included divers, Remotely Operated Vehicles (ROVs) and manned submersibles. The vortices created by the flow was so great that none of these means were fully successful. Finally, a funnel-shaped device 40m diameter was placed over the flow and guided it out to surface vessels for collection until relief wells could be drilled.

If a similar failure occured while drilling at 1,000m or greater, it is speculative whether or not it could be brought under control. The environmental damage could be catastrophic. The major factor which would hinder control efforts would be the absence of a diver. The reason the diver still commands a major share of the offshore oil and gas market during exploration (and development phases) is due to his manual dexterity. There is no manipulator now operating which can replace the diver. While some research and development into mechanical manipulation is taking place, it is inadequately funded and its pace is leisurely. The 1980s will undoubtedly bring this inadequacy in mechanical manipulation to light, but at a cost to the environment. There is an urgent need for vastly increased remote manipulative capabilities at great depths. In terms of the Federal government's responsibilities, it is to assure that capabilities are available to correct sub-sea failures posing serious environmental problems.

Development Phase

This phase consists of site and pipeline surveying, installation of production platforms, pipelines, cables, and drilling additional wells to tap the reservoir(s). Other work involves debris mapping and removal (a legal requirements in Norwegian waters), and abandoned well-head removal. The diver has been the dominant force in this phase also, but greater production depths, more inclement weather and advances in technology have forced him to share a great deal of his work in this phase with other competing systems: the manned submersible, the ROV, and the one Atmosphere Diving Suit (ADS).

Work in the development phase is conducted prior to, during and after installation of platforms and pipelines. Pre-installation work consists primarily of bottom surveys to determine topography and slope, bottom constituents, the presence of debris or hulks and the potential "plowability" or "trenchability" of the bottom. The requirement here is for long-duration missions, and the capability for using side scan sonar, sub-bottom profilers, cameras, bottom-samplers and precision navigation systems.

During installation the work encompasses a variety of tasks. Pipeline installation requires checking that the trench is of proper depth and dimensions, observing that the pipeline is in the trench, observing the external condition of the pipeline and distance measurements. These tasks are shared by the manned submersible, the ROV, and the diver. Structure installation consists of observing grouting operations, measuring the depth of the platform as it is being lowered and the depth of its base after it is lowered, checking guidelines, pipeline and riser welding, and numerous other observation, measurement and manipulative tasks. Much of the work with structures is done in order to direct topside operators of heavy equipment and requires close-up observation. The diver and ROV is now used extensively in this work either separately or in combination. (Comex, for example, put in 24,000 man-hours of saturation diving and several hundred short duration dives to complete the subsea installations on the Argyll field.) One atmosphere bells and submersibles are also used, but not as extensively.

Post-installation work entails seeing that the job was done correctly and clearing away debris. Measurement of pipeline burial depth and inspection for damage. Manned submersibles, remotely operated vehicles and the diver are used in this phase.

The Federal government's interest in this phase also includes the possibility of blowouts, but expands into other areas as well. These areas include vertification that the platform and pipeline are installed as specified, and that debris which may provide obstacles to commercial fishing is removed or, at least, identified and accurately located.

All of the means for pursuing the above responsibilities are available, but are being used at relatively shallow depths (the deepest production platform to date is the Gulf Coast COGNAC platform at 305m depth). At 1,000m only the ROV, manned submersible and ADS are available. These are severely limited by manipulative agility and cable drag/entanglement through the water column and within the structure.

Production Phase

The production phase produces work categorized as maintenance, inspection and repair. Maintenance includes a variety of tasks such as anode replacement, cleaning and/or clearing in-take valves and other "household" chores. This is primarily a diver's function owing to the manipulative dexterity required. Inspection includes debris mapping, checking and measurement for scour, cleaning for detailed non-destructive testing, conducting thickness measurements (generally by acoustics), corrosion potential measurements, crack detection and measurement (by magnetic particle or acoustics), and checking for structure damage brought about by storms, earthquakes, ramming from ships or barges or by large-scale debris dropped from the structure or a supply craft.

Inspection on structures is conducted by free-diving and saturation diving systems, ROVs, ADSs, one-atmosphere bells, and lockout submersibles. The shallow depths (to about 30 ft) are almost always attended by the free diver. Deep depths are handled by any of the other systems. ROVs have begun to significantly penetrate this area. They are limited primarily to external inspection owing to the cable entanglement potential and limited navigating capability inside the structure.

Pipeline inspection in the production phase consists of visually checking for damage (from trawls, anchors, storms or differential settlement); measuring depths of burial (through a combination of magnetic and acoustic sensors) and anode condition measurement. Systems with long-duration, large equipment payload-carrying capability, and maneuverability are required. The ROV and manned submersible are competitors for this job. Recent indications are that the ROV may become dominant.

Repair work consists of tasks which include visual assessment, measurement, cutting, welding and working underwater in conjunction with topside operators of cranes or other lift devices. The diver is the cornerstone of this operation. No other system can provide his manipulative dexterity. Occassionally an ROV is used in conjunction with the diver to direct him or to inspect his work.

The Federal government's role in this phase is primarily in terms of Inspection, Maintenance, Repair (IMR). Not, by mandate, to perform these tasks, but to see that they are properly conducted and on a designated schedule. The production phase generally demands the most varied of capabilities. From a structures point of view it may involve some or all of the following capabilities now provided by the diver (an X to the right indicates tasks which manned vehicles and ROVs have also performed):

welding	
drilling	x
cutting	x
grinding	x
inspection (visual)	x
measurements (dimensional)	x
testing (non-destrictive)	x
video documentation	x
rigging	x
bolting/unbolting	x
assembling	
grouting	
painting	
site investigation	x
directing surface lifting/lowering	x

There are several aspects of these tasks which are significant, the most important being that the diver can do these virtually anywhere on a structure, while vehicles are restricted by virtue of size or by their umbilical to working on the extremities. A second important aspect is that the diver can and does perform a number of these tasks by feel alone and can work in zero visibility. The vehicles, on the other hand, cannot work without seeing the object on which they are working.

Other aspects of diver work vis-a-vis vehicle work must be considered. Rigging tasks with vehicles are generally restricted to attaching a hook or grasping device. The diver cannot only do this, but he can also tie a knot. No manipulator system now in use is known to offer this capability unless the conditions are strictly controlled and favorable. Underwater welding is uniquely the diver's domain. No vehicle today can produce a weld that is in accordance with American Society of Mechanical Engineers requirements; in fact, there is no reported incidence where vehicle operators offer welding services.

The diver is an incredibly versatile tool, and there seems little prospect of matching his performance with mechanical manipulators. Many of the jobs he does, particularly the pre-scheduled tasks, might be performed through remote mechanical means by redesigning the structures so that they are amenable to mechanical manipulation, but the unscheduled tasks where something breaks or loosens, will place demands far beyond the present capability of manned or remote-controlled vehicles if the diver is not available for work at 1,000m and greater.

Not included in the above discussion is the advent of ice. In this case not even the diver can be deployed much more than a few hundred meters inward of the ice cap margins. Since all of the available underwater systems are launched and supported by a surface vessel, and the navigation systems are deployed or carried by the surface support ship as well, then to preclude surface support is to preclude virtually any means of conventional support, either on the water or below the water.

The foregoing discussion of offshore energy needs in terms of undersea support - for the future has concentrated at length on the diver's manipulative capabilities. The absence of this capability in deep water and/or under ice will be critical and, possibly, a major obstacle to obtaining oil expeditiously and safely, and can be a major factor in restraining the potential effects of pollution. There is a pressing need for mechanical manipulative capabilities equal to that of the diver. This need is reflected in the desires of the offshore producer and in the responsibilities of the Federal government.

SCIENCE/POLLUTION

The technological needs of the scientific community in the 1980s can be fairly well predicted on the basis of the programs and requirements already outlined. Specific needs are too diverse to identify, and they would probably verge on the encyclopedic. General needs in specific areas can be more appropriately addressed.

Since the voyage of HMS CHALLENGER in 1872 the marine scientist has been a recurring visitor to the ocean. Initially, research consisted of collecting bottom, water and biological samples for subsequent analyses ashore. When technology permitted, ocean research turned towards real-time measurements and shipboard analyses. Now, the ocean scientist has outgrown his need for gross, one-at-a-time measurements and, instead, seeks a more detailed understanding of the myriad properties and processes his earlier research revealed. This interest is wide ranging: from the shallows to the abyss; from the tropics to the poles. In certain respects the technological needs of the future can be envisioned as the colonization phase of ocean science - a natural progression from the exploratory phase. This colonization is not necessarily a human one, instead, it is colonization through instrumentation; the result of which will be an intimate understanding of the now-explored vast ocean regions.

In many respects the future technological requirements for agencies involved in pollution monitoring and control are similar to those of the scientific community. While spot-to-spot sampling at various periods is pursued, the ideal situation is long-term, near-continuous, monitoring of the water column for specific, man-introduced compounds and/or chemicals. Where the scientist seeks to identify the natural order of the sea, those interested in pollution monitoring and control seek to identify the unnatural.

Examining the needs and requirements of the scientific/pollution programs (actual and potential) delineated previously, the following general trends can be seen:

Greater Depth
Greater Details
Longer Term Measurements
In Situ Data

Each of these requirements and their implications are discussed individually in the following narration.

Greater Depth

Depth is not necessarily an obstacle per se. Most instrumentation is or can be designed to operate at any ocean depth. The problems encountered by greater depths (i.g., greater than 2,000m) are in the support systems, in particular, navigation. Navigation systems are generally categorized as short-baseline and long-baseline. Short-baseline systems involve installing an array of hydrophones (generally 3) aboard the surface ship and an acoustic pinger or transponder on the device which is being towed, guided, followed or planted on the bottom. The position of the undersea object is obtained by acquiring its acoustic signal on the hydrophone array and using the different time of arrival of the same signal to compute the objects position. The spatial separation of the hydrophone is critical, since the angle between the hydrophones and the beacon is used to plot the position. At shallow depths (1,000m or less) the angle is sufficient to produce a position of acceptable accuracy. At 1,000m or more the hydrophone separation is not sufficient to produce an acceptable position. The alternative is the long-baseline system. In this technique transponders are planted on the bottom (generally 3) and the sub-sea object's acoustic pulse is received by these to produce data whereby the object is positioned accurately relative to the three transponders.

The main difficulty with the long-baseline system is in its deployment and recovery. It can sometimes take days to install and calibrate the system, and their is no assurance that all the transponders will be recovered when their work is finished. Furthermore, the long-baseline system (using 3 transponders) can only cover in the area of 4-6km. In order to conduct a wider ranging investigation the transponder network must be recovered and/or replanted and recalibrated. The result is a very time-consuming, laborious and expensive technique.

Greater Details

Predictably, as one's knowledge of specific ocean properties expands, greater details of specific properties are desired. The ocean instrumentation field has made great strides in recent years, but still there is a requirement for more details and accuracy in measurements. An indication of the need for improved instrumentation can be gained by comparing the "present" vs "required" instrumentation needs of Table 1 (taken from the ICMSE Ocean Instrumentation report of 1974).

TABLE I INSTRUMENTATION REQUIREMENTS

PARAMETER	PRESENT CAPABILITIES Expected Range	and Accuracy	REQUIRED CAPABILITIES Expected Range	and Accuracy
OCEANOGRAPHIC				
Depth	0-6000m	±0.25%	0-6000m	±(0.01-1%)
Tides	0-20m	±1m	0-20m	±(0.1-2cm)
Wave Height	0-30m	±5%	0-30m	±(1cm - 10%)
Wave Direction	0-360°	±10°	0-360	±5°
Wave Period	1-40sec	±0.1sec	1-40sec	±0.1sec
Current Speed	1.5-260cm/sec	±2.5cm/sec	0.5-260cm/sec	±0.5cm/sec
Current Direction	0-360°	±3°	0-360°	±(2-10°)
PHYSICAL				
Temperature	-2-40°C	±0.02°C	-2-40°C	±(0.001-0.5°C)
Conductivity	0-70mmho/cm	±0.02ccho/cm	0-70mmho/cm	±(0.001-01mmho/cm)
Salinity	0-48ppt	±0.05ppt	0-48ppt	±(0.003-0.5ppt
Density	10-30σ_t	±0.02σ_t	-1-30σ_t	±0.01σ_t
Light Penetration	10^{-5}-10^{4}lumens, 8000-3000Å	±3%	10^{-6}-10^{4}lumens, 8000-4000Å	±<3%
Sound Speed	1400-1700m/sec	±0.3m/sec	1400-1700m/sec	±(0.02-1m/sec)
CHEMICAL				
pH	0-14pH	±0.2pH	0-14pH	±(0.02-0.1pH)
Dissolved Oxygen	0-15ml/l	±0.2ml/l	0-15ml/l	±(0.01-0.7ml/l)
Sr	100-8000μg/l		0-8000μg/l	
Rb	5-120μg/l		0-120μg/l	
Fe	1-25μg/l		0-25μg/l	
Zn	0.01-10μg/k		0-10μg/l	
U	0.1-3.3μg/l		0-3.3μg/l	
Cs	0.003-0.3μg/l		0-0.3μg/l	
Sb	0.00003-0.2μg/l		0-0.2μg/l	
Hg	0.001-0.3μg/l		0-0.3μg/l	
Co	0.001-0.1μg/l		0-0.1μg/l	
Sc	1x10^{4}-20x10^{-4}μg/l		0-20x10^{-4}μg/l	
Cd	0.001-0.7μg/l		0-0.7μg/l	
Ag	0.003-0.05μg/l		0-0.05μg/l	
GEOLOGICAL				
Sound speed	1400-1800m/sec	±10m/sec	1400-1800m/sec	±1m/sec
Transmission Loss	20kc-1mc		50Hz-10kc	±0.1db
Bulk Density	1.05-2.5g/cm^3	±0.01g/cm^3	1.05-2.5g/cm^3	±0.01g/cm^3
Geomorphology & Physiography	0-11,000m	±4m	0-11,000m	±0.03%
Geomagnetism (Intensity)	20,000-100,000γ	±1	20,000-100,000γ	±0.01
Gravity	977,000-984,000mgal	±4mgal	977,000-984,000mgal	±1mgal
Geothermal Measurements	0-5C	±0.005C	0-5C	±0.001C

Long Term Measurements

The conventional procedures of cruising out to a particular site and obtaining data periodically is giving way to a greater emphasis on installing a device to remain at the site and obtaining the desired data near-continuously over a long-period (a year or more). An indication of the growing importance of this area is the number of deep sea data buoys planted by NDBO which has increased from 11 in 1975 to 21 in 1978. Areas in which scientific investigations over long term periods have been expressed are in the following: water temperatures; currents; corrosion/biofouling; wave properties; sediment movement (surficially and deep); seismic activity; and interval waves. Pollution monitoring efforts will concentrate on oil spills (accidental and intentional), waste dumps (chemical and radioactive) and the by-products of mining/processing operations.

In Situ Measurements

Virtually all geotechnical measurements are made by collecting a sediment sample and analyzing it aboardship for a variety of properties. In many other biological and chemical studies the same procedure is followed. Current and future needs express the desire for measurement of these properties in situ to gain higher accuracy and to avoid the laborious, time-consuming procedures involved in sample collection and analysis. Without doubt, as the need for greater data accuracy increases, the need will follow for more properties to be measured in situ. The needs and requirements expressed in the earlier programs indicate a present need for in situ measurements in the following sedimentological areas: state of stress, gas control, density, permeability, sheer strength, liquefaction and constituents.

If the above four needs (greater depth and details, long-term and in situ measurements) are compared against present capabilities, several supporting technologies are identified which must be advanced. These technologies are: sub-sea navigation; sub-sea power; data processing; data storage; data telemetry and deep-sea vehicles.

a) Sub-sea Navigation: This subject was discussed previously. To recapitulate: there is a growing need for a rapidly-deployable, accurate sub-sea navigation system for depths greater than 2,000m. Ideally, the system would be surface-oriented (i.e., not require deploying objects on the bottom) and integrated into the SATNAV system such that the sub-surface positions can be located on the geodetic sphere.

b) Power: Long-term measurement instrumentation and in situ measurements require power sources with reliable, high power density which will operate in sub-zero to tropic temperatures. The power sources must be light weight, low volume and, to the extent possible, inexpensive.

c) Data Processing: In many instances the investigator will require periodical synopsis of data which is being collected on a long-term basis. Rather than a complete data dump, the need will be for a summation of what the instrument or sensor has recorded over a specified period. (For example, a current data synopsis might include minimum, mean, maximum values for speed and direction.) In other areas the data processing may tend towards obtaining values above and below known mean values. An example of this type discrimination may be found in long-term temperature measurements where the instrument is programmed to record temperatures only above and below a specified mean range.

d) Data Storage: Coincident with data processing, the need for increased data storage capacity for long-term measurements will follow. Storage capacities for two or more years is foreseeable.

e) Data Telemetry: A need is already pressing for through-air transfer of data from moored buoys. In many aspects of marine investigations it is neither practical or feasible to utilize a surface buoy. Instead, the requirement will be for a near-bottom or bottom-mounted instrument independent of a surface connection. In these instances the data transfer will be through water and over ranges measuring in the hundreds and, perhaps, thousands of kilometers.

f) Sub-sea Vehicles: The 1970s saw a great increase in the numbers and varieties of vehicles (both manned and unmanned) employed in undersea work. This trend will continue into the next decade and shows every sign of accelerating. While present capabilities will satisfy relatively shallow open-ocean work, they will not satisfy deep-sea or ice-covered areas. At a recent seminar (Nuclear Wastes - The Ocean Alternative), the need was expressed for a vehicle capable of monitoring and inspecting nuclear waste disposal areas in water depths of 4,000m and greater. The only vehicle in the U.S. which can reach these depths is the U.S. Navy's bathyscaph TRIESTE which is too large, cumbersome and expensive for the task. The Navy's Remotely Operated Vehicle RUWS* had a depth capability of 6,000m, but it was lost in January 1980 in 4,600m of water. In short, there is no current or planned capability to satisfy the nuclear waste monitoring requirements in deep water.

Under-ice investigations will require untethered vehicles. There are two major technological obstacles to effective employment of untethered vehicles: thru-water, real-time TV signal transmission and an independent power supply. Paralleling developments in there two areas will be the need for thru-water command/control capabilities, sub-sea navigation, and high data storage/processing capacity.

*Remote Unmanned Work System

DEEP SEA MINING

The Federal government's interest in deep sea mining is similar to offshore energy, both direct and indirect. According to Cruickshank[2], the Department of the Interior's role is to foster and encourage private enterprise and, pending passage of legislation, assume management of resources in selected areas. NOAA's responsibility includes bathymetric mapping and charting, and environmental monitoring of the deep sea. NSF, under the IDOE program, has, since 1972, sponsored research into the genesis, distribution, detailed structure and geochemistry of nodules.

Deep sea mining or, more specifically, manganese nodule mining, has been theorized, discussed, studied, re-studied and re-discussed for the past 30 odd years. A few tentative at-sea experiments into the environmental impact of mining and more serious efforts at assaying and surveying nodule deposits have been, and are being, conducted. But the promise remains a promise. It is still impossible to predict, although some have had the courage to do so, what the future holds for deep sea mining. Two factors play a dominant role; they are political and economic.

For the past six years the Law of the Sea Conference has been trying to reach international agreement concerning: who owns the deep sea deposits; who will be allowed to mine them; who will share the expense in the mining operations if they are permitted; and how will the profits be distributed. The Conference is now going into its tenth year and appears to be not much closer to agreement than when first convened.

The economics of nodule mining are more clear cut. At this point in time the mining, processing and transporting of deep sea nodules (the richest deposits being found to date between 4300 to 4900m depth) does not appear economically justifiable. Private industry, although interested, has yet to invest the large capital resources necessary to begin nodule extraction.

On the positive side is a projection made by Pollock[3] in a report on NOAA's DOMES (Deep Ocean Mining Environment Study) activities:

> "We anticipate that commercial production will involve several mining ships each capable of recovering from 5,000 to 10,000 metric tons (dry weight) of nodules per day, and operating 24 hours per day for about 300 days per year. Our projections show two to four units operating by 1985, with a mature industry probably consisting of 30 to 40 units by 2010 AD."

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[2]Cruickshank, M.J. 1975 The Federal Government Role in Marine Hard Minerals Mining. Proc. Ocean '75, Mar. Tech. Soc., Wash., D.C., p. 621-624

[3]Pollock, H.W. 1977 DOMES Studies and Deep Ocean Mining. Jour. Mar. Tech. Soc., V. II, n. 3, p. 27-29.

Whether or not the 1980s will see actual, at-sea commencement of manganese nodule mining is speculative. Until recovery techniques which have been conceptualized have been actually employed, there is little or no precedent for anticipating technological needs except in broad areas. These areas have been noted and identified by the National Academy of Engineering and were presented earlier in this report.

FUNDING SUPPORT ESTIMATES (FY 80)

The following information was obtained from published sources (specifically, Sea Technology's 1979-80 Buyers Guide/Directory) and from the personnel interviewed in the course of this study.

DEPARTMENT OF COMMERCE
NOAA

(In millions of dollars)

Activity	FY 80
Mapping, charting & surveying services	$ 47.7
Ship support services	46.3
Ocean fisheries and living marine resources	118.6
Marine ecosystems analysis and ocean dumping	18.6
Marine technology	15.5
Sea Grant	35.2
Coastal Zone Management	66.0
Basic environmental services	134.4
Environmental satellite services	91.7
Public forecast & warning services	88.6
Specialized environmental services	41.9
Environmental data & information services	23.0
Global monitoring of climatic change	4.0
Weather modification	7.7
International projects	8.8
Retired pay, commissioned officers	3.0
Executive direction & administration	33.4
Coastal Energy Impact Fund	4.0
Fishing Vessel & Gear Damage Compensation Fund	3.5
Fishermans Compensation Fund	.6
Total	$792.5

Office of Ocean Engineering FY 79 budget	$ 14.0 million
Deep Ocean Dumping FY 79 budget	$ 2.3 million

DEPARTMENT OF DEFENSE
ONR

(In millions of dollars)

Activity	FY 80
Physical Oceanography	$ 10.5
Chemical Oceanography	2.6
Biological Oceanography	3.0
Geology/Geophysics	6.9
Acoustics/Optics	4.7
Ocean Engineering	1.7
Other Navy Labs	3.6
Total	$ 33.0

DEPARTMENT OF ENERGY
Ocean Systems Branch

Activity	(In millions of dollars) FY 80
OTEC	$ 35.0
Other Energy Sources	1.0
Total	$ 36.0

Division of Waste Isolation

Feasibility studies on sub-sea disposal FY 80 $ 5.9 million

DEPARTMENT OF THE INTERIOR
USGS

Conservation Division[4]

Activity	(In millions of dollars) FY 80
Structural Verfication	$ 5.0
Well Control	5.0
Environmental Concerns	5.0
Total	$ 15.0

Office of Marine Geology

Activity	(In millions of dollars) FY 80
Oil and Gas Research Assessment	$ 10.8
Energy Related Environmental Investigations	8.3
Marine Geology	1.3
Total	$ 20.4

DEPARTMENT OF TRANSPORTATION
USCG

Pollution Response (budgetary estimates)	
Self-propelled skimmers	$ 1.0 million/ea.
Skimmer Barriers	$ 0.2 million/ea.
Air Deployed Anti-Pollution Devices	$ 0.06 million/ea
Surveillance and Monitoring (to design, construct, install in situ sensors by FY 82)	$ 3.0 million

[4]The OCS Land Amendment of 1978 mandated that USGS be given the responsibility of assuring that industry uses the Best Available and Safest Technology (BAST). Approximately one-half of the total budget will be directed toward this end.

NATIONAL SCIENCE FOUNDATION

Activity	(In millions of dollars) FY 80
Deep Sea Drilling Project	$ 15.4
Ocean Margin Drilling	2.1
IDOE	17.4
Polar Program - Artic	6.0
- Antarctic	55.0
Total	$ 68.7

U.S. CONGRESS
Office of Technology Assessment

Ocean Research Technology	$ 0.4 million

COMPREHENSIVENESS OF DATA COVERAGE

This study was, as mentioned earlier, a general overview of the field. It would seem appropriate, therefore, to attempt to estimate the extent of coverage this study represents. Such an estimate is extremely difficult to obtain in view of the lack of specificity in the reports reviewed.

In July 1969 the National Council on Marine Resources and Engineering Development published Marine Research Fiscal Year 1968, a catalog of unclassified marine research activities sponsored during FY 1968 by Federal and non-Federal organizations. This catalog contains descriptive summaries of 2,589 unclassified projects underway in that fiscal year. Twelve project categories are listed, of which Engineering and Technology is one. (A listing of seven projects is enclosed on the following page which was copied from the above report.)

Of the 2,589 total projects listed, 344 fall into the Engineering and Technology category. Of these, 163 were funded/supported by the civil arm of the Federal Government. (The remaining 180 were funded by the Navy, Army, Air Force, private industry, universities, and state governments.) Within the Engineering and Technology Category are 14 sub-divisions: 1) aquaculture; 2) biomedical engineering/life support; 3) cargo handling; 4) coastal engineering; 5) general ocean engineering; 6) instrumentation; 7) equipment design and standards; 8) power systems; 9) hydrodynamics; 10) materials; 11) mineral sampling, extraction and processing; 12) platform design and maintenance; 13) sanitary engineering; and 14) underwater construction. Of these subdivisions 1, 3, 4, 13 and one-half of the projects in 12 did not apply to this study. The total number of projects within those pertinent sub-divisions was 275.

At this point, in order to obtain some estimate of coverage, the assumption is made that the ratio of Engineering and Technological projects in FY 1968 to other marine-oriented R&D is the same as in FY 1980 as it was in FY 1968. This assumption must be made since there has been no other publication since 1969 that specifies and describes Federal projects with such comprehensiveness. (The Council, as such, was disbanded shortly thereafter, no other group has assumed its activities in this regard, although the Committee on the Atmosphere and the Ocean is its progeny.)

If the above assumption is valid, then the coverage in this study (72 active/planned projects) represents only 25 percent of the potential total based on the 1968 ratios.

8. ENGINEERING AND TECHNOLOGY

8.0102, DEVELOPMENT OF FISHNET BATHYKMORGRAPH
J.E. CROSSEN, U.S. Dept. of Interior, Biological Laboratory, *Woods Hole, Massachusetts*

Purposes: To develop an instrument system that can measure the time, duration, and depth of each haul made by New England Groundfish fishermen as a precise measure of fishing effort.

To provide acceptable hardware for a model of a standard system that will minimize the total cost of the complete operation from data collection to the printing of the final format. Specifically, to provide 20 fish-bathy-kymographs (FBK's) (DSE) for analogue readout including calibration equipment, and spare parts kits in accordance with contract 014-17-0007-820 and the assurance that the acceptance criteria have been met.

Approach: Contract development of the model system to a commercial contractor (Geodyne Corp.) with a Bureau coordinator and project leader (Mr. Crossen) in the Lead Laboratory (Woods Hole). Oceanographic Instrumentation will coordinate the efforts of the Branches concerned with this project. A reliability engineering support contractor (Arine Co.) will supply services at prescribed check points.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

8.0103, SHIPBOARD GRAVITY SENSOR AND GYROCOMPASS
C.O. BOWIN, Woods Hole Oceanographic Inst. , *Woods Hole, Massachusetts* 02543

A Sperry Mark 19 gyrocompass will be modified into a Mark 19c comfiguration and a Bosch Arma vibrating-string accelerometer will be mounted aboard ship so as to function as a sea gravimeter similar to that developed by Von Arx and Wing.

SUPPORTED BY U.S. National Science Foundation

8.0104, INSTRUMENT STUDIES
D.C. WEBB, Woods Hole Oceanographic Inst. , *Woods Hole, Massachusetts* 02543 (N00014-66-C0241)

The objective of this task is to provide advanced and comprehensive engineering support for a wide range of scientific and observational programs. This support will be achieved through the evaluation of promising but unproven techniques, acquisition and testing of new components, and investigation of causes of failure. Work will be done in the laboratory and in the field.

It is expected that this work will generally benefit the program at the institution by improving new instruments. This in turn will improve competence available to the Navy for general oceanographic efforts.

SUPPORTED BY U.S. Dept. of Defense - Navy

8.0105, INSTRUEMTATION FOR LAKE CAYUGA HEAT RELEASE STUDY
D.H. BOCK, Cornell Aeronautical Lab. Inc. , *Buffalo, New York* 14221

Instrumentation has been designed, developed, calibrated, and installed for recording temperature profiles and flow rates at several points in Lake Cayuga in the vicinity of a fossil-fueled power plant. Four buoys and one rigid pole in the lake were used for the instrumentation installations, from which temperature and flow rate information is transmitted to shore via coaxial cable. (This cable also carries power for the instruments and low frequency command signals for sampling various instruments at the buoys and the pole.) The signals which measure the flow rate and temperature are frequency modulated with an analog of the variable being measured. Time division multiplex is used for sampling of up to 24 signals from each of the buoys and the pole and to permit transmission of the data via the one coaxial cable. At the shore, the data can be extracted and recorded in digital or analog format. A digital-to-analog converter is available to permit monitoring of signals on a paper chart recorder. The sampled signals are connected to a telephone line to permit access to the data at a central location where equipment maintenance can be initiated, when necessary.

SUPPORTED BY New York State Electric & Gas Corporation

8.0106, STUDY OF PROBABILITY OF DETECTION AND FALSE ALARM RATE OF FREQUENCY ACOUSTIC TELEMETERING SYSTEM
R.A. HELTON, Raytheon Company, *Portsmouth, Rhode Island*

The penalty for a false actuation by an acoustically-controlled underwater oil well may be drastic in terms of the human lives and capital resources which could be lost. A study of the effective false alarm rate that may be achieved with an acoustic frequency diversity telemetering system, consistent with a high detection probability, has been completed. An acoustic link must face hazards of high noise levels, multiple reflections, reverberation, and temperature inversions. Our study has evaluated these basic phenomena theoretically within the limits of our knowledge of the statistics of the noise field, of the variability of the medium, and the likelihood of particular forms of man-made interference. The system has been tested at sea, and data pertaining to the assembling of background statistics has been collected.

We have demonstrated that systems may be designed with an acceptably low risk of false actuations, while achieving positive detections reliably. The study indicates that only modest power would be required to achieve satisfactory operation at ranges which permit operation over the full extent of the Continental Shelf.

SUPPORTED BY Raytheon Company

8.0107, DEVELOPMENT OF A SENSOR, INSTRUMENTATION AND COMMUNICATION SYSTEM FOR A DEEP OCEAN MANNED HABITAT (ATLANTIS)
O.H. JACKSON, Raytheon Company, *Portsmouth, Rhode Island*

Technical Description: Conceptual development of electronic systems for a manned habitat for occupation of the ocean floor at 6,000 feet was initiated. Particular emphasis was directed to: communications between habitat and surface; communication between habitat and telechiric devices; communications between men in the hyperbaric environment and the habitat; fail-safe emergency communications on several levels; navigation systems for precise localization and elevator mating; remote positioning and control of telechiric devices; long range acoustic sensing systems; sensors for the acquisition of physical, chemical biological and geological data; data handling to ensure crew safety; data handling to process and analyze the sensor information.

This effort involved basically the evolution of the electronic systems necessary to support a long term manned mission on the edge of the shelf or on the mid-Atlantic ridge.

SUPPORTED BY Raytheon Company

8.0108, FEASIBILITY STUDY FOR A GATED-LASER, IMAGE-AMPLIFIER UNDERWATER VISION SYSTEM
T.W. SMITH, Raytheon Company, *Portsmouth, Rhode Island*

The growth in man's ability to exploit the oceans has made obvious the need for systems to identify underwater objects and to provide information for the direction of work. Underwater television provides a limited capability which must be extended for operation in turbid water. This program accomplishes a significant performance improvement through the application of a blue-green YAG laser for illumination, a Raytheon night vision image converter, a range gate for selecting the range of interest and a television system for delivery of the resulting image to a remote viewer. The program has included analytical study and experimental verification of results.

SUPPORTED BY Raytheon Company

8.0109, EXPERIMENTAL HIGH RESOLUTION SUB-BOTTOM PROFILING SYSTEM
G.M. WALSH, Raytheon Company, *Portsmouth, Rhode Island*

An experimental replica correlation echo sounder system is being developed, including transducer, power amplifier, receiver and signal processor. This system will experimentally verify performance of large time-bandwidth product (WT) signal processing for the measurement of depth and sub-bottom profiling, with potential signal processing gains of 23 db. The increased signal energy provided by the large WT signals will significantly improve measurement resolution and provide capability for

Reference was also made earlier to the regional offices of the various agencies and the probability that they are conducting research and development projects not revealed during the personal interviews conducted or literature reviewed during this study. These omissions can account, to an unknown degree, for missing programs.[5]

In the final analysis, there is, unfortunately, no available yardstick by which to measure the comprehensiveness of this study. Two alternatives exist: 1) expand this study to include regional and local offices; or 2) utilize a service offered by the Smithsonian Institution.

The Smithsonian Institution offers a service which could be of considerable help. (The following is extracted from NOAA's 1978 Guide to Information on Research in Marine Science and Engineering.) The Smithsonian Science Information Exchange, Inc. (SSIE) located in Washington, D.C., was established in 1949 by six federal agencies engaged in the sponsorship and performance of research in the medical sciences. Over the years SSIE has expanded both the scope of its coverage and the extent of its services. Today the Exchange receives project information from over 1,300 organizations that sponsor research, including federal, state, and local government agencies; nonprofit associations and foundations; colleges and universities; and, to a limited extent, foreign research organizations and private industry. The active search file, which covers the two most recent fiscal years, now contains more than 200,000 descriptions of ongoing or recently terminated projects in all fields of science; nearly 6,000 of these are in marine science and engineering and closely related fields.

The basic record in the SSIE system is the singlepage Notice of Research Project (NRP), which contains the data elements essential to most users of the file: supporting organization name and control, grant, or contract number; performing organization name and address; investigator name(s); project title; period for the description; and a 200-word technical summary of the work to be performed. In some cases, funding information is also included.

To meet a variety of user needs, the Exchange has developed a wide range of information products and services.

Custom Searches. In response to individual requests, staff scientists search the active file for NRP's on specific subjects. Searches for NRP's from particular performing organizations or departments, for geographic areas, or for any combination of similar requirements can also be made. Estimates of coverage and costs for specific custom searches are available without charge.

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[5]The January 1980 issue of Sea Technology (p. 25) reports that 1,000 pollution-related Federal programs with an aggregate budget of $187 million in FY 1980 are in existence.

Selective Dissemination of Information (SDI). The Exchange offers two types of SDI service for users who wish to receive regular updates of custom searches or research information packages (see below). SSIE scientists establish a user interest profile for each SDI subscriber; then periodic searches of the active file are conducted against this search profile to identify all new or newly updated project notices added to the data base since a previous search was made.

Subscribers to Standard SDI Service receive 12 monthly search updates, compiled automatically by computer. Custom SDI Service provides subscribers with quarterly updates, each of which is reviewed by a staff scientist to assure maximum relevance of update contents to search profile requirements.

Investigator or Accession Number Searches. Searches of the active file can be performed by principal or co-investigator name, or by SSIE accession or agency control number.

SDC/SSIE On-Line Search Service. The SSIE data base is available on-line for users with access to a computer terminal who wish to search the file directly. Further information about this service can be obtained from Systems Development Corporation (SDC) at 2500 Colorado Avenue, Santa Monica, California 90406, or 7929 Westpark Drive, McLean, Virginia 22101.

Aides developed by SDC and SSIE to assist on-line users in conducting searches through the SDC system include manuals describing SDC's retrieval program applications, a guide to the SSIE subject indexing system, and a three-volume computer printout of over 90,000 SSIE Subject Terms and Synonyms.

Research Information Packages. SSIE scientists regularly conduct and review searches of the active file for NRP's on topics of high current interest. The results of these searches are compiled into research information packages which, once established, are available at costs that represent significant savings over those for custom searches. Package contents are updated every 90 days.

Prices vary according to the average annual number of NRP's expected to be included. Because the contents of the data base fluctuate, packages compiled at different times during the year may contain NRP counts outside the range indicated by their published price.

APPENDIX A

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APPENDIX B

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APPENDIX C

EXPLANATION OF TERMS USED IN FIGURE 3

INSTRUMENTATION

Underway - Mounted semi-permanently to the ship's hull to measure depth, water temperature, currents, etc.

Towed - Deployed by cable from the ship while underway. Examples: side scan sonar, sub-bottom profiler.

Expendable - Deployed from the ship, generally underway, to measure temperature, sound velocity, salinity as a function of depth. These instruments are attached to a cable, when they reach a prescribed depth the cable breaks and the instrument is abandoned. Examples: XBT (expendable bathythermograph); XCTD (expendable conductivity, temperature, depth).

In Situ (Short Term) - Measurement on the site or in situ (as opposed to collecting a sample and anlyzing it on the surface) of a particular property, such as, sediment bearing strength, permeability or porosity.

In Situ (Long Term) - Same as above, but the measurements are generally of dynamic properties over a long (months) period of time. Such measurements include measurement/monitoring of: sediment movement, seismic activity, storm surge effects on the sea floor.

Bottom Sampling - Collection of bottom sediment cores in an undisturbed condition.

Boundary Layer Sampling - Undisturbed sampling of the very thin zone constituting the sediment/water interface.

Sub-Bottom - Generally consists of acoustic measurements of features (e.g., strata, sand/gravel deposits) below the sediment/water interface.

Structural NDT - Instruments to conduct non-destructive testing of steel and concrete structures. For example, magnetic particle inspection, ultrasonic thickness/flaw measurements, radiographic flaw detection.

Survey Mapping - Refers to a variety of instruments used to gain a 3-dimensional facsimile of the sea-floor, its constituents, topography and sub-bottom features. These instruments include: echo sounders, side scan sonars, sub-bottom profilers, seismic profilers, sampling devices, cameras, TV, etc.

Airborne/Remote - Refers to a device needed to take color photos or acoustic imagery of the sea surface for purposes of plankton identification, surface current measurements or wave characteristics.

DATA ACQUISITION, PROCESSING, LOGGING

A variety of requirements/developments fall into this category; they include: development of a remote command/interrogate technique between NSTL and remote stations via NESS; satellite interrogation to obtain data dumps from unmanned sensor systems; improvement of data link monitor to Coast Guard stations, etc.

- COMMUNICATIONS

Refers to improvements and/or developments in voice communications. These include: reduction of interference on HF/SSB voice channels; investigating the feasibility of a future satellite communication system ship-to-shore (e.g., MARISAT).

NAVIGATION/POSITIONING

The requirements in this category are all surface positioning. They include: development of electronic interfacing of shipboard positioning systems to a common ship parameter network; develop automatic input of ship's speed and heading into SATNAV units; improvement of dual yagi shipboard satellite antenna systems.

MATERIALS

Refers to research into fracture mechanics, weld-derived stresses, characteristics of materials, etc., of structural materials for OTEC and pipelines.

POWER SOURCES

Requirements in this category refer to development/improvement/investigation into power sources. These include: examination of alternate power cycles (in OTEC) to the ammonia vapor power cycle, development of power systems for NOAA data buoy.

SEA POWER UTILIZATION

Refers to a variety of schemes to extract power from tides, waves, currents, and thermal gradients.

EQUIPMENT (SHIPBOARD)

These problems deal with improvements to shipboard equipment, such as, winch capabilities, loading stresses on cables, data logging techniques, etc.

MOORING/ANCHORAGE

Conduct an analytical study of the anchoring and mooring system of an ocean turbine.

UNDERSEA VEHICLE CAPABILITIES

Refers to improvements in vehicle (submersibles, remotely operated vehicles, one-atmosphere diving suits) capabilities in the areas of manipulation, data telemetry, communications, tooling.

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